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Fourth.—A well-marked curved rillen from the spots northward of *Bernouilli.*
Fifth.—A straight rillen from *Bernouilli* northward.

N.B. This ephemeris will be available for any subsequent lunations by just altering the dates to suit the ages of the moon in September and following months, and by careful observation the times of the first appearance of the rillen and other features may be detected.

Description of Various Processes made use of for Finding out the Configuration of Optical Surfaces. By M. Leon Foucault.

(*Communicated by Mr. De La Rue.*)

"One of the principal advantages of the reflecting telescope consists in having, instead of an object-glass, a mirror which acts by means of a single surface; which surface being concave lends itself with remarkable facility to the application of the processes of examination which permit the appreciation of its figure even to the least details.

"I conjointly make use of three different processes. The first consists in placing very near to the centre of curvature a very small object, such as the point of a pin, in order to obtain an image of the same size as, and very near to the object itself; this image can then be observed by means of a microscope and compared directly with the object. We are thus enabled to judge with certainty by means of the amount of definition, of the effect which the mirror mounted as a telescope will give.

"If the image is imperfect, it is better then, with the view of ascertaining the faults of figure, to take a luminous point and observe the appearance of the pencil of light within and without the focus. It will be seen to decompose itself in partial images, the discussion of which gives at once some information respecting the configuration of the surface of the mirror.

"But the two processes I am about to point out are still preferable and give this information with greater precision.

"An object having parallel sides, such as the edge of a thin piece of steel, having one millimètre ($0^{\text{in}}\cdot03937$) in thickness is placed in the neighbourhood of the centre of curvature, and in order that the object may project itself in outline it is enlightened from the side opposite to the mirror, and the image which is formed by it, being on a luminous ground, becomes very apparent, and presents in its aspect some peculiarities which depend upon the figure of the mirror. This image being observed with the naked eye at the distance of distinct vision is seen in each of its parts, but, by means of rays passing through the

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pupil after having been reflected from a very small part of the surface of the mirror, so that in these circumstances the mirror only acts but partially, that is, by more or less restricted portions of its surface, which contribute severally to the formation of different parts of the image. Thus, if the curvature be not uniform, the different parts of the image will not form themselves in the same plane, and the angles subtended at the eye by the different parts will not be proportional to the corresponding part of the object; in short, the image will be deformed, contractions and dilatations will be seen, showing a decrease or an increase of the radius of curvature of the corresponding element of the mirror. The method becomes more correct and more conclusive, if instead of allowing the edge to have an indeterminate position in space, we fix on the eye-piece of a small telescope, magnifying but little, and provided with a narrow diaphragm comparable with the pupil.

"It is very rare that an image observed in such way will show itself free from any distortion, and such as a perfectly spherical mirror would give it, the edges instead of remaining rectilinear are bent most frequently in the shape of an hyperbola, and turn their concavity towards the interior of the field of the telescope; in presenting themselves under that shape they indicate that in every meridional section of the mirror the curvature goes on gradually diminishing from the centre towards the edge, which tends to correct to a certain degree the spherical aberration.

"Lastly, it remains now to describe a process which allows of the examination concave surfaces, so as to recognise directly, by an effect of relievo, the elevated and depressed parts which affect the figure.

"A thin piece of metal, pierced with a small hole having $\frac{1}{12}$th of a millimètre ($0^{\text{in}}{\cdot}00328$, or about $\frac{1}{305}$th of an inch) and enlightened by an artificial light, is placed within the centre of curvature, through that little hole the diverging pencil of rays falls on the surface which is being examined and comes back converging to form an image which is situated a little beyond the centre.

"By placing the eye in the cone of rays which diverge anew, and in bringing it towards the image, we at last receive the whole of the pencil of rays which passes freely through the pupil, and at the same time the surface of the mirror will be seen entirely illuminated. Now, if an opaque and rectilinear edge is brought near the image of the hole and be made to infringe on it by degrees, the mirror will also lose by degrees its brilliancy, and when all the light is about disappearing, the whole of the irregularities of the surface of the mirror will be plainly seen.

"In fact, supposing the surface to be correctly spherical, the image is perfectly well defined, and when allowed to emerge a little from the opaque screen which is brought forward to in-

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tercept it, the rays which are not stopped off come from the whole surface of the mirror which presents to the last a uniform brilliancy; if, on the contrary, this surface shows here and there some parts which are situated above or below the spherical level, the elements which do not present themselves under the proper incidence, these cause certain rays to deviate instead of converging with their fellow-rays (*congenères*) towards the different parts of the image and to be dispersed in all directions.

"It results from this that every point of the image, and in particular each of those which emerge from the opaque screen, receives rays which do not belong to it, and does not receive those which do belong to it.

"The missing rays will leave in their corresponding places on the surface of the mirror a deficiency of light, the accumulated rays will produce an increase of intensity in others, and from the contrast of these different degrees of brilliancy and on account of an effect *clair-obscur*, an enormously exaggerated manifestation of the inequalities which really exist on the surface submitted to this sort of test will result.

"As the observation can only be made by means of a single eye, it happens that under a moral influence independent of the the will of the observer, the valleys and hills seem to overlay each other; but with a little attention, what is a mere illusion will soon be distinguished from reality. In considering that the true rising parts are necessarily contained between two opposite declivities, one of which being turned towards the screen which hides the image appears dark, whilst the other presents an increase of brilliancy. In other words, the true figure of the mirror is analogous to that which would correspond to the apparent relievo interpreted in that hypothesis, in which an oblique light would come from that side opposite to the screen.

"This process offers, particularly, the advantage of being at the same time expeditious and direct; viz., a surface can be judged of in a few seconds, and, when it is defective, the faults of it are known immediately with great precision.

"Generally, all that has any influence on the direction of the rays, or anything which prevents them from converging simultaneously towards a point of common convergency, becomes visible and is found out. By means of this sort of observations, among several causes which affect the result, that one which exercises a predominant influence is easily distinguished from the rest. Thus the permanent irregularities of a surface will not be mistaken for the varying alteration due to the flexure of the mass of glass; and we can perceive the inequalities in the density of the ambient air which passes in whirling before the mirror, or which shows itself like stratified layers in the interior of the tube of the telescope. By taking the necessary precautions, all causes capable of producing an accidental disturbance are successively avoided, and the intrin-

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sical faults or defects of the surface are the only ones which subsist.

"But, guided by the observation itself which causes them to be discovered, one succeeds, as I have demonstrated before, in correcting locally these defects; and lastly they can be reduced to such proportions as to exercise no sensible influence on the quality of the images.

"The mechanical processes by which the working of glass surfaces is usually effected seem to lose of their efficacy as soon as they are applied to pieces of unusual dimensions; the results which they then furnish are but an approximation, a sort of trial which is far from being satisfactory; but where mechanism becomes powerless, the hand of man can do something more: assisted by the resources which optics put at his disposal, and guided by a system of observations the power of which increases with that of the instrument which is to be constructed, the human hand is then enabled to proceed with the work, and to carry it out to the greatest degree of precision.

"If it be required to verify by optical means any one of the ellipsoidal surfaces which lead from the sphere to the paraboloid, the same process can be applied identically, on condition, that the object which is used as a mark is placed at one of the foci, and the image examined at the other focus. The information which is got thereby, and the corrections which must be deduced therefrom, are based on the same appearances; only they have reference especially to the sort of surface given by the position of the foci, and the inequalities which are found out show deviations which are reckoned in the same way as for the spherical figure, viz., from the level of the correct surface which it is desired to obtain."

On a New Method of Clearing Lunars.

By Lieut.-Col. R. Shortrede.

The following method of clearing a lunar distance gives a result always true to within a few hundredths of a second, and, requiring few logarithms, and these too from five to three places, is shorter and easier than any other I am acquainted with:—

m, M, and s, S, being the true and apparent places of the moon and star, and perpendiculars $m\,\mu$, $s\,\sigma$, being drawn to M S, the apparent distance $m\,s = \mathrm{M\,S} - \mathrm{M}\,\mu + \mathrm{S}\,\sigma + \mathrm{I}\,m - \mathrm{I}\,\mu + \mathrm{I}\,s - \mathrm{I}\,\sigma$.

For the principal corrections Mμ, Sσ, the proper expressions are

$$\tan \mathrm{M}\,\mu = \tan \mathrm{M}\,m \cos \mathrm{M}$$

and $$\tan \mathrm{S}\,\sigma = \tan \mathrm{S}\,s \cos \mathrm{S}$$